09/701910
525 R PCT/PTO 05 DEC 2000

SUBSTITUTE SPECIFICATION: CLEAN COPY

09701910.120501

09/701910
525 Rec'd PCT/PTO 05 DEC 2000

AP9265

Device and Method for Actuating a Brake System for Automotive Vehicles

Technical Field

The present invention generally relates to vehicle brakes, and more particularly relates to a device and a method for actuating a brake system to accomplish a brake assist function, especially for automotive vehicles.

Background of The Invention

Active brake force boosters are known in the art which are used to shorten the stopping distance. The brake force booster referred to is actuated independently by a so-called brake assist system. The mode of operation of the brake assist system which improves the braking power of a vehicle when driven by a less experienced driver and, thus, shortens the stopping distance is e.g. as follows. A travel sensor measures the speed of depression of a brake pedal. When the driver hesitates after the spontaneous application of the brake pedal and does not dare to fully depress the pedal until response of the control of an anti-lock system (ABS), the brake assist system will intervene. An electronic control device calculates from the speed by which the braking operation was initiated by the driver whether emergency braking prevails and sends, by way of a magnetic valve, a command to the booster operating in the ON/OFF mode to deliver the full boosting force. The result is that the vehicle is braked in a boosted manner. To prevent the triggered brake assist system from inadvertently decelerating the vehicle until standstill, a release switch is integrated into the booster. The switch will switch off the brake assist system as soon as the driver releases the brake pedal again. The above principle is e.g. described in German patent DE 42 08 496 C1.

However, the above solution suffers from the disadvantage that an inadvertent quick application of the brake pedal may also trigger independent activation of the brake system. Further, it may occur in an unfavorable case that the system is retained in the independently actuated and activated condition when the driver applies a relatively small amount of force to

the brake pedal (after the activation by e.g. a quick depression of the brake pedal). This may also lead to an undesirable braking operation. When the brake assist system senses that release of the active booster is desired by the driver, further, a jerk may occur because the brake pressure is reduced suddenly.

An object of the present invention is to provide a device and a method for actuating a brake system to perform a brake assist function, especially for automotive vehicles, which achieve safe and comfortable shortening of the stopping distance and avoid unintentional activations.

According to the present invention, a brake pedal can be used which is uncoupled from the brake system inasfar as the quantities, such as the actuating travel of the brake pedal, which are input by the driver into the system and are variable and depend on further inputs, such as the speed of pedal depression, may be converted by a control unit into the vehicle deceleration to be effected by the brake system.

It should be noted in this respect that it is of course possible to use other input variables for converting the driver's input by way of the brake pedal into the desired deceleration. For example, these variables could be the vehicle speed, vehicle load, a measured yaw torque, the current steering angle, etc.

According to the present invention, for example, damping and/or a counterforce of the brake pedal can be adjusted accordingly by way of a control unit, and the control unit can reduce the damping effect and/or the counterforce of the brake pedal accordingly when the brake assist function is activated, and the resulting actuating travel of the brake pedal which is determined by way of a travel sensor of the brake pedal may then be taken into account for determining the deceleration that is to be effected by the brake system.

According to the present invention, it may thus be ensured in a favorable manner that total control of the brake system by the driver is effected when the brake assist function is activated. This is in contrast to the state of the art described hereinabove because the brake

assist system in this prior art actuates the brake system by a corresponding control logic partly independently of the actual position of the brake pedal. This is prevented in the present invention because the deceleration of the brake system is adjusted in dependence on the determined actuating travel (actual position) of the brake pedal. Because the damping effect and/or the counterforce of the brake pedal is reduced, it has to be expected that the driver depresses the brake pedal to a greater extent than in the event when the brake assist function is not activated so that the deceleration effected by the brake system is augmented. The result is a reduced stopping distance.

According to another embodiment, a control unit can change a brake force acting in the system, when the brake assist function is activated, in dependence on an actuating travel determined by the travel sensor, an actuating speed and/or an acceleration of actuation of the brake pedal. The brake force acting in the system can correspond to a ratio of the determined actuating travel to a deceleration to be effected by the brake system. According to this embodiment, the counterforce and/or damping effect of the brake pedal will not change, instead, the driver's input by way of the brake pedal is boosted to a greater extent so that a shortened stopping distance can also be achieved when the brake assist function is activated.

The above embodiments may of course also be implemented in a combined fashion.

Brief Description of The Drawings

Figure 1 is a schematic block diagram of the present invention.

Figure 2 is a graph showing the actuating travel of the brake pedal plotted against the actuating force.

Figure 3 is a flow chart for changing the damping effect and/or the counterforce of the brake pedal.

Figure 4 is a graph showing the counterforce (input force) of the brake pedal or the output force of the brake system which is proportional to the deceleration, plotted against time.

Figure 5 is a flow chart relating to an increase of the brake force acting in the system.

Detailed Description of The Preferred Embodiments

A brake pedal 1 with a travel sensor 2 is shown in Figure 1. The travel sensor 2 can sense the actuating angle of the brake pedal 1 or the actuating travel of the brake pedal 1. The travel sensor 2 is connected to a brake system 4 and, especially, to a control unit 5 by way of a corresponding signal line 3.

In response to the signals of the travel sensor 2 (or the angular sensor), the control unit 5 initially determines whether a brake assist function is required. If this is the case, the control unit 5 will determine, for example, a correspondingly reduced counterforce of the non-illustrated pedal components of the brake pedal 1. These pedal components may include a static portion (spring) and a speed-responsive portion (damping effect). The reduction of the counterforce may be achieved by minimizing damping effect, for example. This may be performed by varying the hydraulic effective cross-section.

The control unit 5 may also leave the damping effect and/or the counterforce of the brake pedal 1 unchanged and increase the brake force acting in the system accordingly when the brake assist function was activated. Of course, influencing the counterforce and/or the damping effect of the brake pedal 1 and of the brake force acting in the system may also be combined.

Depending on the signals sensed by the travel sensor 2 (or angular sensor), a deceleration to be effected by the brake system 4 is now determined by the control unit 5 of the brake system 4. This is done, for example, with the assistance of the determined actuating travel, the

determined actuating speed, and/or the determined acceleration of actuation. Of course, other factors may also be taken into account (for example, the vehicle speed, a yaw velocity, a steering angle, etc.).

Depending on the determined deceleration or the determined braking pressure, wheel brakes 6 are now actuated by way of corresponding control lines 7 in order to bring about the desired deceleration (only one wheel brake 6 is shown for the sake of clarity). The control lines 7 may be electric and/or hydraulic control lines to actuate the wheel brakes 6.

The embodiment of Figure 2 shows a graph of the actuating travel plotted against the actuating force (or the input force F_e) of the brake pedal 2. When the brake assist system is not actuated, an actuating travel of the brake pedal 1 of x1 is produced with an actuating force F_{e1}. When the brake assist system is activated, an actuating travel x2 is produced with the same actuating force F_{e1} of the brake pedal 1. By reducing the damping effect and/or the counterforce of the brake pedal, a stronger or deeper depression of the brake pedal 1 by the driver will be achieved, so that the braking distance can be reduced effectively without impairing the entire control of the braking action or braking operation by the driver. The same applies also to the embodiment according to Figures 4 and 5 (as will be explained in the following).

The purpose of the flow chart according to Figure 3 is to represent a possible operating sequence which is executed, for example, by the control unit 5. This sequence is started in step 100, and a poll is made in step 101 whether the brake assist system or the brake assist function is activated. If this is not the case, a line branching back in between steps 100 and 101 is made.

As has already been explained hereinabove, activation of the brake assist function may be induced, for example, by the control unit 5 when the speed of depression of the brake pedal 1 is higher than a threshold value (this is, however, meant only as an example for a possible activation input of the brake assist function).

Subsequently, a branch to step 102 is made in which the damping effect and/or the counterforce of the brake pedal 1 is reduced. This may be effected in that hydraulic effective cross-sections of the brake pedal 1 are varied accordingly. Subsequently, the actuating travel x of the brake pedal 1 is sensed in step 103, and deceleration that corresponds to the actuating travel is determined in step 104. Then, the determined deceleration is output to the brake system in step 105, and the wheel brakes 6 are subsequently actuated so that this deceleration is reached. The above-mentioned operating sequence terminates in step 106.

The static counterforce of the brake pedal 1 (spring and/or damping effect) may thus be limited to a value which corresponds to a thirty percent braking, for example, because the normal range of action of the driver comprises 0 to 30 % deceleration, that means, the driver knows this range of deceleration or the range of the pedal counterforce. This effects an accelerating force surplus of the pedal force on the brake pedal 1, whereby a quicker foot movement and a stronger or deeper depression of the brake pedal 1 takes place. Thus, the pedal travel that results is an indicator of the deceleration to be achieved. The value for the counterforce to be adjusted may e.g. depend on the speed of application of the foot (sensed by the speed of application of the brake pedal 1). Further, a static counterforce (spring effect) which is responsive to the pedal travel can be reduced to a value which e.g. corresponds to a thirty percent braking (lower force-travel characteristic curve). This also effects an accelerating force surplus of the pedal force on the brake pedal 1 and, thus, a quicker foot movement. Still further, the dynamic counterforce (damping effect) can be reduced to a value of the application speed which is possibly responsive to speed, and it should be taken into consideration in the reduction of damping that the tendency of the brake pedal to vibrations (inherent movement of the brake pedal 1) is reliably prevented. In this arrangement, the static pedal characteristic curve would be maintained, and only the motion-hindering damping force would be reduced.

The pedal travel that results is an indicator of the deceleration to be achieved in all solutions mentioned hereinabove. Of course, all above possibilities can also be combined in any fashion desired.

It should be noted in this respect that the effect of a conventional driver actuation switch can be described by sensing the pedal movement because the pedal is not moved actively.

Figure 4 shows an increase of the brake force acting in the system. The dotted lines show the input force F_e (corresponds to the counterforce) and the output force F_a. The output force F_a is a value which corresponds to the vehicle deceleration. When the brake assist system or the brake assist function is switched on, the brake force acting in the system will be augmented. The uninterrupted solid line shows maximum boosting. After the brake assist system is switched off, the brake force acting in the system will re-approach the normal brake force so that normal brake force will prevail again in the next actuation of the brake system. The approach to the normal brake force takes place continuously or gradually so that the brake force acting in the system is reduced as comfortably as possible.

Of course, any steps desired between the dotted line of F_a and the uninterrupted solid line of F_a are possible. Intermediate values for the brake force acting in the system may be chosen, for example, in dependence on the actuating travel, the actuating speed, and/or the acceleration of actuation of the brake pedal 1 so that the boosted course of the output force F_a is between the solid uninterrupted line and the dotted line. Naturally, the determination of the brake force acting in the system and, thus, also the line representing said may also depend on other factors (for example, the vehicle speed, the vehicle weight, etc.) at a defined time during the activation of the brake assist function and after the activation of the brake assist function (in the phase of the continuous approach to the normal brake force).

A possibility of an operating sequence which can e.g. be executed in the control unit 5 is shown as an example in Figure 5. After start in step 200 there is a branch to step 201 by polling whether the brake assist function is activated or not. If this is not the case, a branching

back in between steps 200 and 201 is made. When the brake assist function is activated, the brake force acting in the system is augmented in step 202. Subsequently, the actuating travel of the brake pedal 1 is sensed in step 203. Then a deceleration which corresponds to the sensed actuating travel is determined in step 204, and the brake force acting in the system that is augmented in step 202 is taken into consideration. The deceleration is then output to the brake system 4 in step 205, and the operating sequence terminates in step 206.

When the brake assist function is activated, the mathematical brake force acting in the system (actuating travel or pedal travel in relation to deceleration) is greatly augmented, and the counterforce of the brake pedal 1 is uninfluenced. The resulting brake force acting in the system may depend on the pedal movement (actuating travel, actuating speed and/or acceleration of actuation) and is fixed during the application of the brake (positive pedal speed). During release of the brake, the brake force acting in the system is reduced continuously again until the normal brake force is reached.

The embodiments according to Figures 2 and 3 as well as 4 and 5 may also be combined, of course.

Further, it should be noted that the modules and functions described in the present invention may be realized alone and/or in any combination desired.